Developing Methods to Create Orthomosaic Image from Historical Aerial Imagery

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Introduction

Aerial photography is a remote sensing technique that has been used since the early 1930s to understand landscapes along flight lines and to record changes in the earth's surface (Morgan et al., 2010). By collecting landscape-scale remote sensing data at the same location at different times, it is possible to visualize changes in timely series. Today, advancements in technology, particularly new cameras and computer hardware and software, have improved dramatically our ability to generate three-dimensional (3D) models from aerial imagery using collinearity equations and bundle block adjustment through Structure from Motion (SfM) software. Nebiker et al. (2014) state that historical aerial photographs provide tremendous opportunities to reconstruct a landscape in 3D when dense image matching technology appropriately computes the depth of any given point in the historical aerial images. I hypothesize that the SfM approach can be successfully applied to historical aerial photographs on the Island of Hawai`i and accurate orthomosaic images can be created.

Objective

To explore and develop a method to create an orthomosaic image from historical aerial imagery in 1954

Study Area

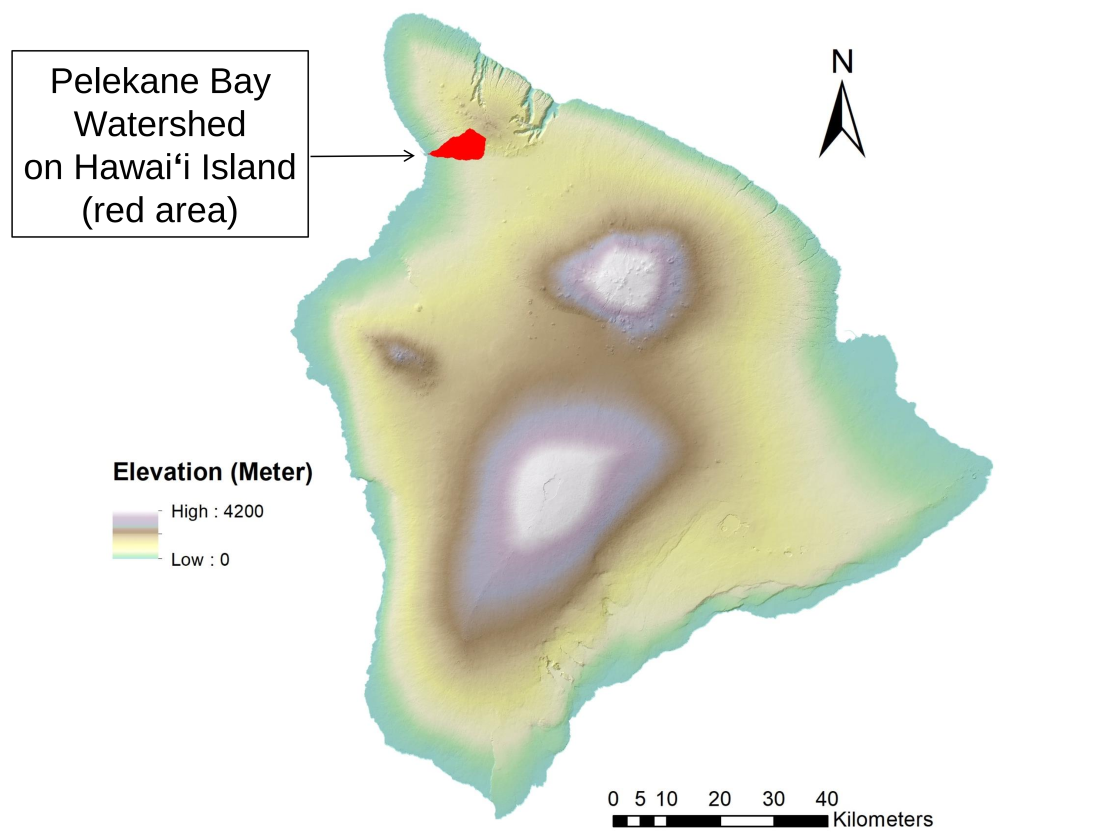


Figure 1: Pelekane Bay Watershed on Hawai`I Island

Credit: DEM by Coastal Geology Group at UHM & Pelekane Bay Watershed shape by NOAA OCN

Data

- Image Captured Year: 1954
- Image Type: Grayscale
- Camera Calibration Report: Not Available

- Source of Images and Image Details
  1. NOAA Digital Coast
     a) Size: approx. 15 MB per image
     b) Dimensions: Approx. 5,000 by 5,000 pixels
     c) Resolution: 96 dpi
  2. Hamilton Library at University of Hawai‘i at Mānoa
     a) Size: 300 KB per image
     b) Dimensions: Approx. 2,400 by 2,400 pixels
     c) Resolution: 254 dpi
  3. United States Geological Survey (USGS)
     a) Size: approx. 100 MB per image
     b) Dimensions: Approx. 10,000 by 10,000 pixels
     c) Resolution: 96 dpi

Methods

- Trial and Error Approach
- Software used:
  - Agisoft Metashape
  - ENVI
  - Pix4D
  - Adobe Photoshop
  - ArcGIS Desktop

Successful Method

- Data: USGS (24 images)
- Software 1: Adobe Photoshop
  - Eliminate all pixels outside of the image area
  - Manually align the image to straight
  - Automate Batch
    - Adjust a canvas size of all images to be the largest image's canvas
    - Align all images to be center of the canvas
    - Crip and remove fiducial marks
      - ✓ All 24 images to be in the same size
- Software 2: Metashape (Structure from Motion Software)
  - Align
    - Quality: Medium
    - Key Point Limit: 100,000
    - Tie Point Limit: 10,000
  - More steps to generate an orthomosaic image

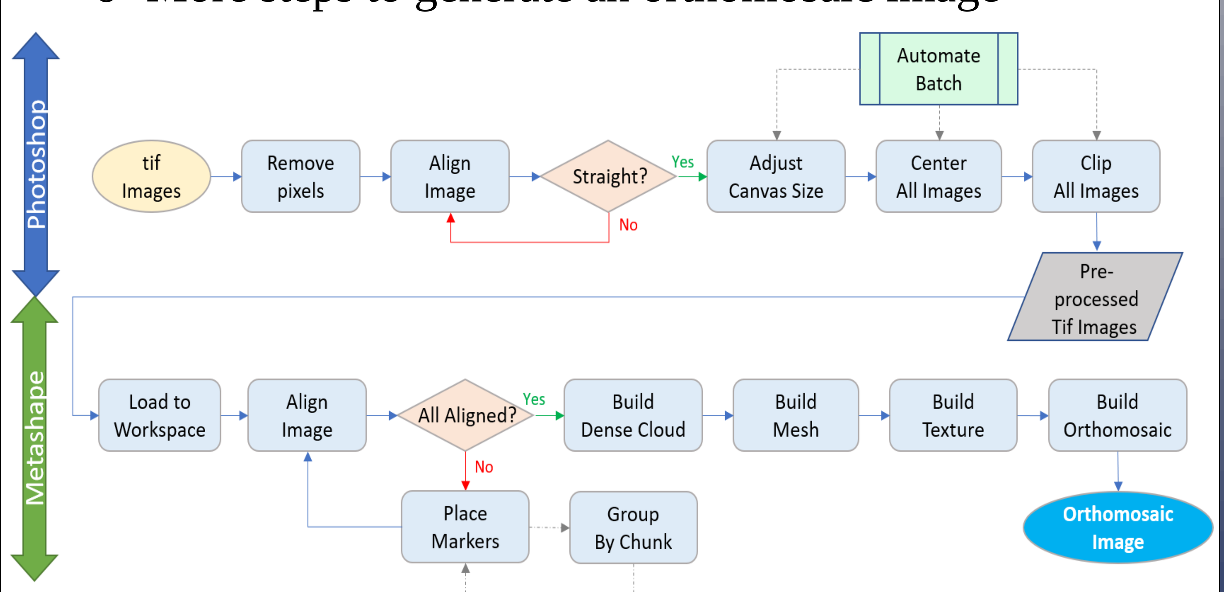


Figure 2. Process workflow chart

Results

1. Detected Key Point: 100,386 points (Approx. 4,180 key points per image)
2. Detected Tie Points: 96,185 ties
3. Key Point Usage: 95.8 %

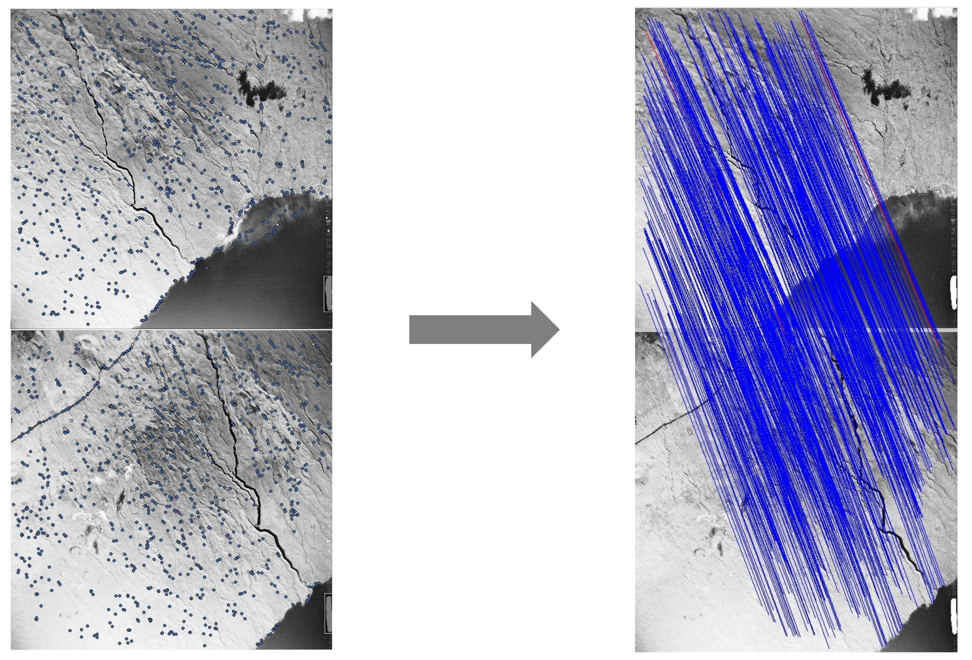


Figure 3. Key points and tie points

4. Image Overlapping: Majority of images overlap twice (orange) to three times (yellow) along flight line. Side overlapping is ranging from four (sage) to six times (green).

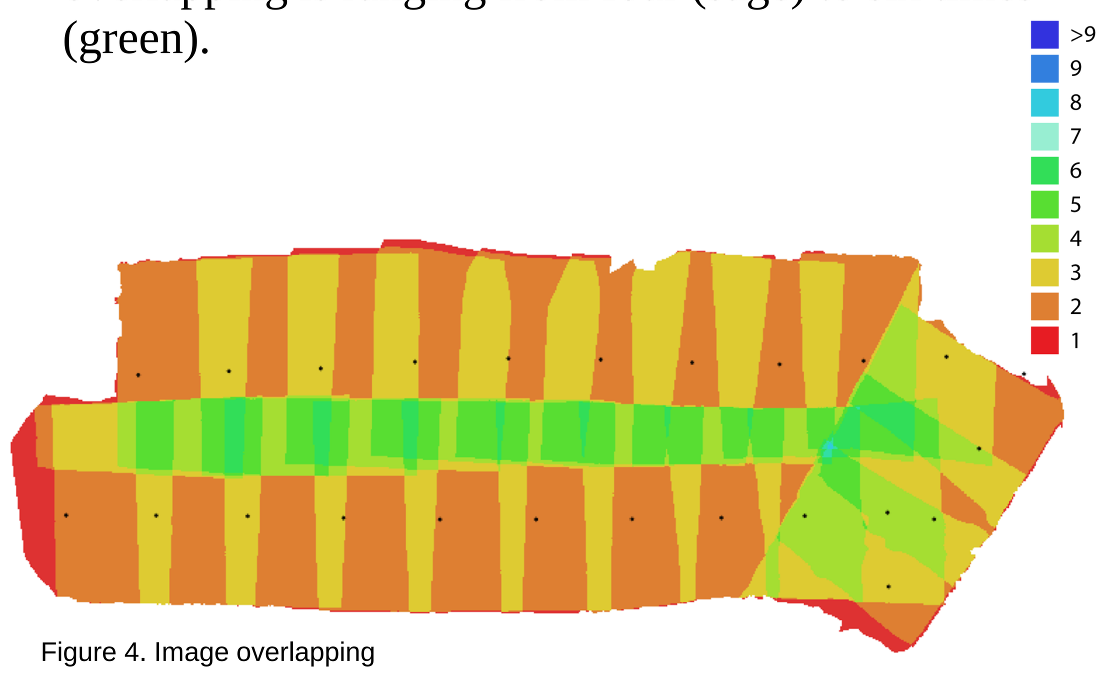


Figure 4. Image overlapping

5. Point clouds and image locations: Point clouds are formed according to the image film locations at the time of photo taking.

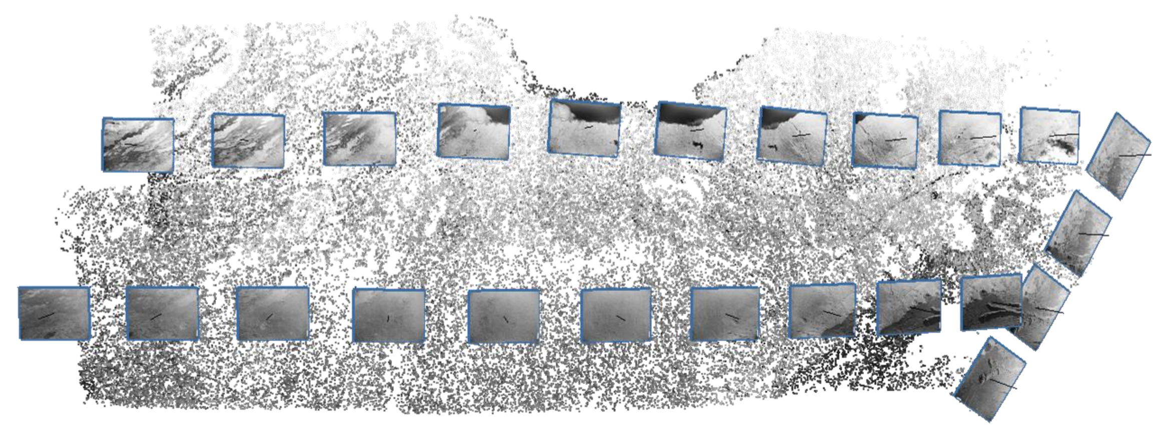


Figure 5. Vertical view of dense point clouds and camera locations

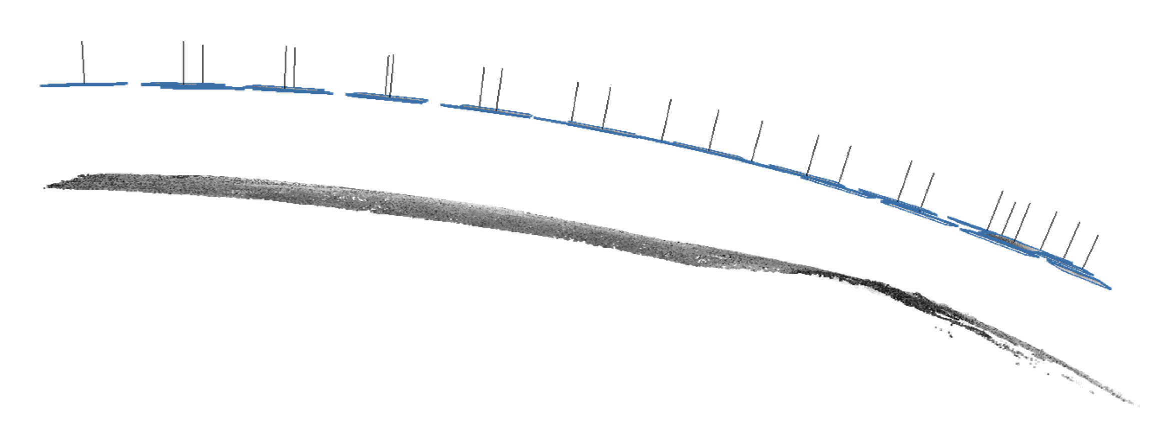


Figure 6. Horizontal view of dense point clouds and camera locations

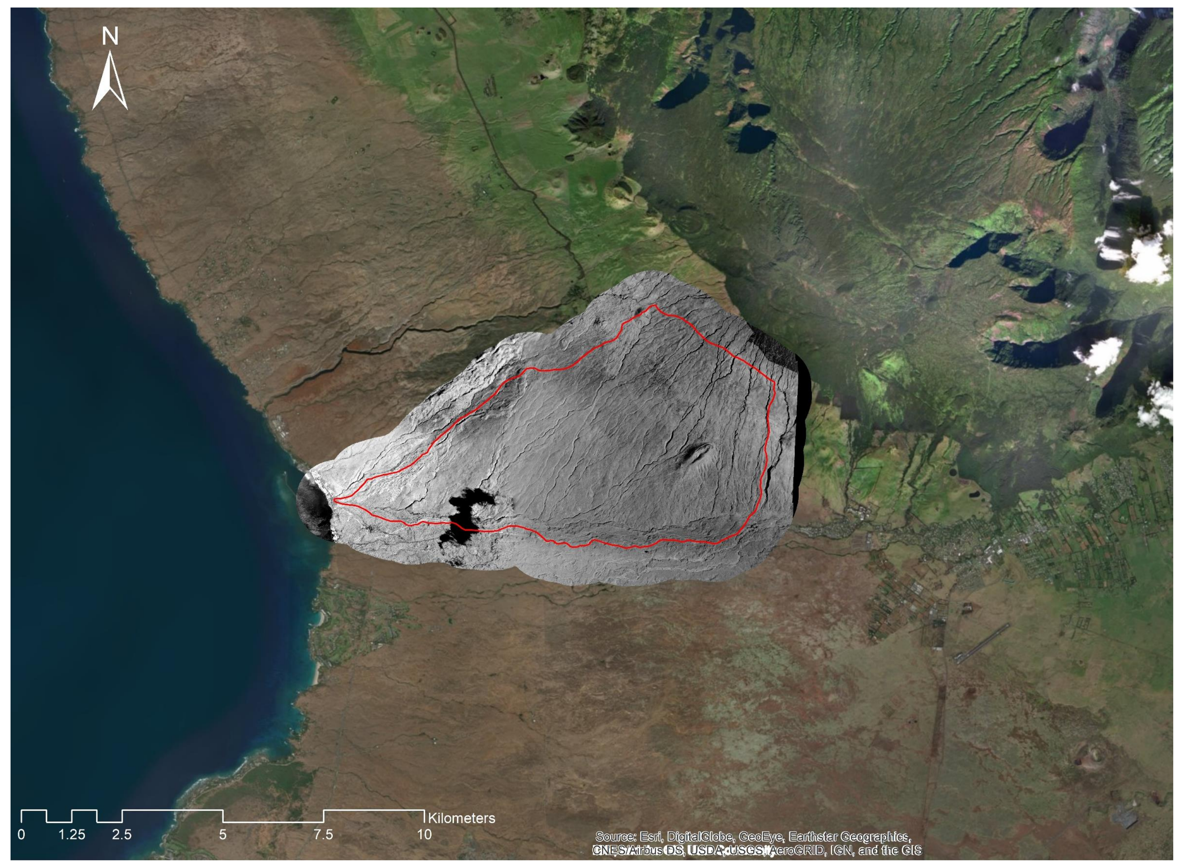
Discussion

Through 38 trials, a successful method was developed to create an orthomosaic image from historical imagery for the study site (Figure 1) using Adobe Photoshop and Agisoft Metashape (Figure 2). Each of 37 failed results suggested the reasons for failures such as significantly a smaller number of aligned images, little or no tie points, and a minimal amount of image overlapping. Increasing the number of detected keypoints created more chance to tie the key points resulting in more images were mosaicked together. Key point usage was 95.8%, which indicated most of the keypoints were used to generate dense point clouds (Figure 3).

Pre-processing each image in AdbePhotoshop significantly enhanced Metashape to detect the number of keypoints and tie points. Larger the number of tie points, higher the accuracy of the dense point cloud because a higher number of tie points helped computation of collinearity equation and bundle block adjustment through SfM software.

In addition to the high usage of keypoints to make tie points, a couple of other factors also contributed to the accurate dense cloud generation. According to the image overlapping (Figure 4), all 24 images overlapped each other. This image overlapping was significantly crucial because overlapping in larger area and a more significant number of images provided more reference to calculate the accurate location information. Camera locations corresponding to the dense point clouds illustrated how the image film locations were determined through dense point cloud computations. Figure 5 and Figure 6 clearly indicated how the airplane flew to capture those images, which match to the flying path (Figure 5) and flying height (Figure6) information of USGS. All of these results validated the accuracy of the dense point clouds.

Pre-processing the images to increase the number of tie points was the most important step to create an orthomosaic image.



Conclusion

In conclusion, through 38 trial and error approaches, I identified that the most effective method to create an orthomosaic from grayscale historical images. The successful method was to first pre-process the historical aerial imagery through Adobe Photoshop, then process them in SfM software, Metashape, to reconstruct historical landscapes.

Acknowledgement

This Developing Methods to Create Orthomosaic Image from Historical Aerial Imagery Project is a part of PIPES Program at the University of Hawaii at Hilo and funded by Office for Coastal Management at National Oceanic Atmospheric Administration. I am grateful for Katie Taladay's in guiding and encouraging me to complete the work.

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